Tutorial -8 (Combustion and Chemical Equilibrium)

1. A fuel, C_xH_y, is burned with dry air and the product composition is measured on a dry basis to be: 9.6% CO_2, 7.3% O_2 and 83.1% N_2. Find the fuel composition (x/y) and the percent theoretical air used. (14.9) Ans: x/y=.461, %theoretical air =149%

2. Pentane is burned with 120% theoretical air in a constant pressure process at 100 kPa. The products are cooled to ambient temperature, 20°C. How much mass of water is condensed per kilogram of fuel? Repeat the answer, assuming that the air used in the combustion has a relative humidity of 90%. (14.11) Ans: 1.247kg/kg of fuel; 1.492kg/kg of fuel

3. Methanol, CH_3OH, is burned with 200% theoretical air in an engine and the products are brought to 100 kPa, 30°C. How much water is condensed per kilogram of fuel? (14.14) Ans: .781 kg/kg of fuel

4. Pentene, C_5H_{10} is burned with pure oxygen in an SSSF process. The products at one point are brought to 700 K and used in a heat exchanger, where they are cooled to 25°C. Find the specific heat transfer in the heat exchanger. (14.16) Ans: q= -373738kJ/kmol of fuel

5. Butane gas at 25°C is mixed with 150% theoretical air at 600 K and is burned in an adiabatic SSSF combustor. What is the temperature of the products exiting the combustor? (14.31) Ans: Tp=2048K

6. In a rocket, hydrogen is burned with air, both reactants supplied as gases at P_o, T_o. The combustion is adiabatic and the mixture is stoichiometeric (100% theoretical air). Find the products dew point and the adiabatic flame temperature. (14.32) Ans: T-flame= 2524 K, t_dew=345.6K

7. Liquid butane at 25°C is mixed with 150% theoretical air at 600 K and is burned in an adiabatic SSSF combustor. Use properties for the liquid fuel and find the temperature of the products exiting the combustor. (14.33) Ans: 2039K

8. Carbon dioxide at 15 MPa is injected into the top of a 5-km deep well in connection with an enhanced oil-recovery process. The fluid column standing in the well is at a uniform temperature of 40°C. What is the pressure at the bottom of the well assuming ideal gas behavior? (15.1) Ans: 34.36Mpa

9. Consider a 2-km-deep gas well containing a gas mixture of methane and ethane at a uniform temperature of 30°C. The pressure at the top of the well is 14 MPa, and the composition on a mole basis is 90% methane, 10% ethane. Determine the pressure and composition at the bottom of the well, assuming an ideal gas mixture. (15.2) Ans: P2 =16.044 Mpa, Y_{Ch4}= .889

10. Hydrogen gas is heated from room temperature to 4000 K, 500 kPa, at which state

the diatomic species has partially dissociated to the monatomic form. Determine the equilibrium composition at this state. (15.11) Ans: $y_{H2} = 0.497$, $y_H = 0.503$

11. One kilomole Ar and one kilomole O_2 is heated up at a constant pressure of 100 kPa to 3200 K, where it comes to equilibrium. Find the final mole fractions for Ar, O_2, and O. (15.13) Ans: $y_O = 0.1358$; $y_{02} = 0.3981$; $y_{Ar} = 0.4661$

12. Saturated liquid butane enters an insulated constant pressure combustion chamber at 25°C, and *x* times theoretical oxygen gas enters at the same pressure and temperature. The combustion products exit at 3400 K. Assuming that the products are a chemical equilibrium gas mixture that includes CO, what is *x*? (15.16) Ans: x=1.957, y_co=.106, y_co2=.1428, y_h2o=.311, y_o2=.44 (do by mass action)

13. A gas mixture of 1 kmol carbon monoxide, 1 kmol nitrogen, and 1 kmol oxygen at 25°C, 150 kPa, is heated in a constant pressure SSSF process. The exit mixture can be as s umed to be in chemical equilibr ium w ith CO_2, CO , O_2, and N_2 pres ent. The mole fraction of CO_2 at this point is 0.176. Calculate the heat transfer for the process (15.24) Ans: Q_{CV}=176787 kJ, T=3212K

14. A rigid container initially contains 2 kmol of carbon monoxide and 2 kmol of oxygen at 25°C, 100 kPa. The content is then heated to 3000 K at which point an equilibrium mixture of CO_2, CO, and O_2 exists. Disregard other possible species and determine the final pressure, the equilibrium composition and the heat transfer for the process. (15.25) Ans: p2=782.2 Kpa, Qcv=-175959 kJ, yco2=.574, yco=.069 yo2=.356

15. Methane at 25°C, 100 kPa, is burned with 200% theoretical oxygen at 400 K, 100 kPa, in an adiabatic SSSF process, and the products of combustion exit at 100 kPa. Assume that the only significant dissociation reaction in the products is that of carbon dioxide going to carbon monoxide and oxygen. Determine the equilibrium composition of the products and also their temperature at the combustor exit. (15.34) Ans: T=3233K, yco=.107, yco2=.082, yh2o=.378, yo2=.432